found, they are not thermoluminescent, nor can they be made so by exposure to radium. Moreover they are not decolorised by moderate heating.

As already explained, there is reason to believe that hyacinths are formed from these opaque zircons by the action of a bath of molten basalt. It was attempted, and with partial success, to imitate this experimentally. Basalt was kept melted in a platinum crucible over a gas furnace, and some opaque zircons immersed in it for 24 hours. After this they were extracted, and found to be quite white, though not transparent. On exposure to radium they now took on the redder colour of hyacinths and became, like them thermoluminescent.

The only outstanding point is the transparency of natural hyacinths. This may result in some way from the gently increasing, very prolonged action of the molten basalt under geological conditions, which cannot be artificially imitated.

Intermittent Vision.

By A. Mallock, F.R.S.

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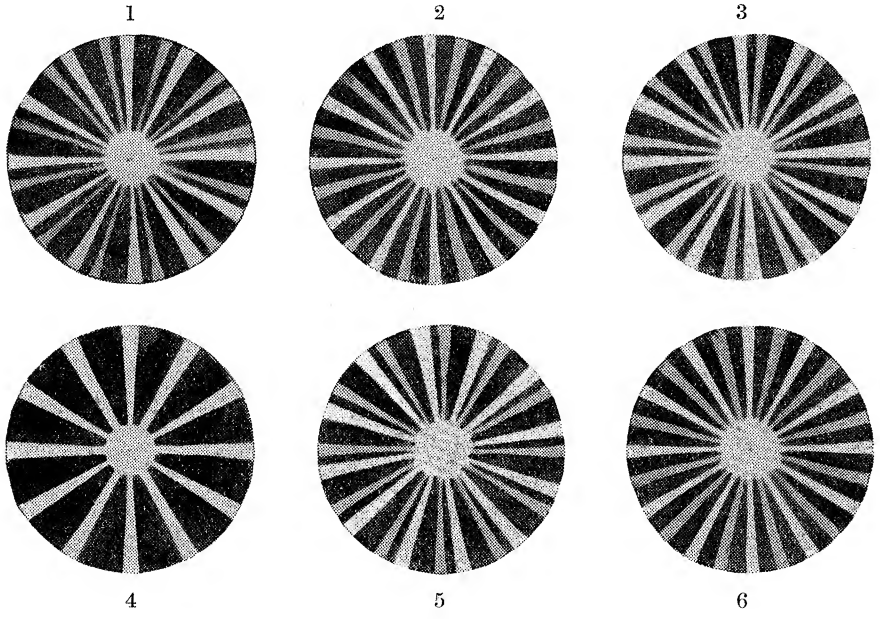
It is a matter of fairly common observation that the spokes of the wheels of passing motor cars often appear momentarily stationary, and sometimes even seem to be turning in the direction opposite to their actual motion. It was pointed out to me by the Hon. T. F. Fremantle that these appearances, which last only for a small fraction of a second, coincide with the steps of the observer, and are only noticeable when the speed of the vehicle lies between certain limits. On the one hand the motion must be too quick for the eye to follow the individual spokes, and on the other it must not exceed a certain limit, which is apparently slightly different for different individuals.

To examine the phenomena more closely and conveniently a 4-inch disc of black paper was prepared, on which 12 equally spaced radial white lines were superposed, and the disc was mounted on a heavy top, running on ball bearings, and which when spun lost its speed slowly. An electric contact on the top in conjunction with a recording chronograph gave the angular speed at each instant, while another pen worked by the observer allowed signals to be marked on the chronograph paper, indicating according to a code the nature of the appearance of the disc in various circumstances.

It was found that the lines on the spinning disc appeared stationary not

only at each step, but that any slight mechanical shock, such as is given by gently tapping the head or body, or by working the jaws or by winking, was equally efficacious. When the speed was so low that only 9 or 10 lines passed a fixed point in a second, the appearance was merely that of ordinary "flicker" and when 80 or more lines passed in the same time the surface looked uniformly grey, and in both cases mechanical shock had no apparent effect.

Figs. 1–6 give an idea of the impression received at various speeds of rotation.



Figs. 1–6.

The first thing noticeable after the angular velocity drops to about six revolutions per second (*i.e.* about 70 lines per second) is that at each shock the uniform grey surface seems to break into a number of radial lines; it is difficult to estimate their number, but a guess would put it between 40 and 50. This is the conventional way in which rapid rotation is suggested in drawings. When the speed has dropped to about 4·5 revolutions per second, the lines appear equally spaced (*i.e.* at intervals of 15°), fig. 6. At three revolutions per second the appearance is that of fig. 4, the lines being separated by their natural intervals of 30°. Above and below this speed the lines again are grouped in pairs (figs. 3 and 5), and at 1·5 revolutions, the spacing becomes uniform at 15°, see fig. 2, rather better defined than in the corresponding fig. 6.

At a lower speed still the lines again appear in pairs (fig. 1), but now flickering tends to obscure the effect.

The intensity of the light has a good deal of influence on the result. In a feeble light very little can be seen of stationary images, and when the light is very strong flickering interferes before the stage shown in fig. 2 is reached.

An explanation of the above-mentioned phenomena can be given on the assumption that a slight mechanical shock of any kind produces a periodic but rapidly extinguished paralysis of the perception of light. (I have reason to believe that something of the same kind happens as regards sound but the observations in this case are not so easily made.)

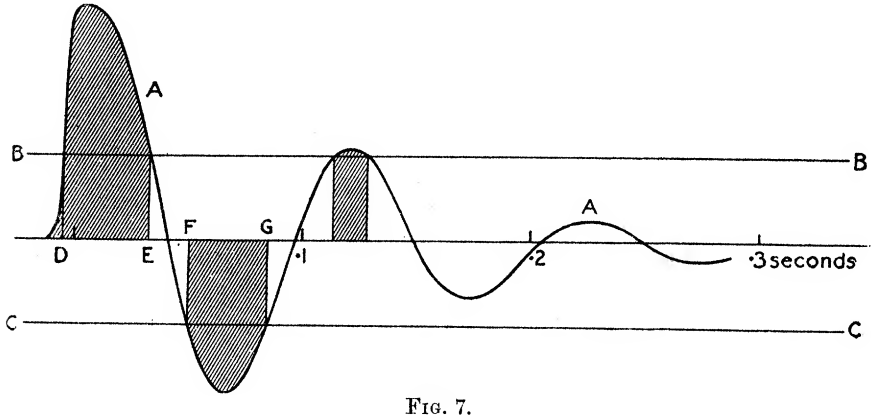


FIG. 7.

Suppose that the nerves on which "seeing" depends cannot bear more than a certain amount of mechanical acceleration without loss of sensibility, and let the curve A, fig. 7, represent the mechanical acceleration consequent on a shock or blow of any kind. Let B and C be two lines giving the limits of acceleration which does not produce loss of sensation.

Then the effect of the shock will be to extinguish the image of a bright object for the times indicated by the length of the shaded parts of diagram. The first recurrence of the image after the shock will last for a short time only, and thus if the object is in motion a fairly defined image of it will be seen at a distance from the first disappearance equal to its travel in the time DE.

As the vibration consequent on the shock dies out the time of visibility increases, the next eclipse being represented by FG, and so on.

For the class of shocks which are considered here only two or at most three secondary images can be made out.

More severe shocks cause a displacement of the directions of the eye

which displaces the image on the retina, and it is difficult to say what is seen; but mechanical displacement of the image on the retina without loss of sensibility does not explain the observed facts. For, in this case, only those lines would be affected which were considerably inclined to the direction of vibration; and although the direction of the vibration (*e.g.* the application of the shock to the top or sides of the head) has some effect on the pattern of the stationary lines, the differences are not large, and any shock makes all the radial lines visible, though in a slightly different degree.

If the explanation suggested in this paper is correct it will be seen from fig. 7 that there are two intervals of eclipse to each complete vibration, and that since, when the disc makes three revolutions per second, the lines have turned through their natural interval of 30° before sensibility is restored, the period is 18 per second.

The chief interest of this intermittent vision lies in the definite period involved. What determines the period, however, is not clear; it may be merely the mechanical period of the head on its elastic supports, or on the other hand it may be a period belonging to the brain or nerves. That such a slight shock as that caused by opening the eyelids is effective, rather suggests the latter origin, whilst the fact that when the shock is caused by tapping the head or body the effect increases with the strength of the blow, is more consistent with a vibration of the head as a whole.